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THE JACK-IN-THE BAG FIXED VOLUME LIFT DEVICE.(U)
FEB 81 R W BUECHER
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ADMINISTRATIVE INFORMATION

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The basic operating principles of the Jack-in-the-Bag fixed volume lift device are described. A description, operating instructions, and test results for the 500-lb capacity prototype are presented.

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OBJECTIVE

Determine the feasibility of using the Jack-in-the-Bag collapsible lift device in construction diver applications.

RESULTS

The Jack-in-the-Bag prototype was demonstrated successfully in both the test pool and the open ocean. Changes in its net buoyancy were made easily and accurately.

RECOMMENDATIONS

Further development of the device for fleet use should be considered.

CONTENTS

ILLUSTRATIONS

INTRODUCTION

An inexpensive and convenient way to provide buoyant lift underwater is to trap a bubble of air. This is commonly done by putting air into a lift bag or open bottom pontoon. Unfortunately, the buoyancy provided by this type of device is unstable. When the device rises slightly, its air bubble expands, its buoyancy increases, and it will rise faster. If it sinks slightly deeper, its air bubble compresses, its buoyancy decreases, and it will sink faster.

When an ordinary lift bag is used to lift a load which is less than its full capacity, it will start to rise toward the surface before the bag is full of air. Then, as the air expands, the buoyancy of the bag increases, and the speed of the bag and its load increases, possibly to the point of going out of control. In addition, when the bag reaches the surface, it may porpoise out of the water high enough to spill some of its air. Then, as it settles back into the water with its load, it may sink back down to the bottom.

In using an air bubble to provide buoyancy, it is advantageous to constrain the air volume so that small depth changes produce changes in relative pressure between the air and the outside water rather than changes in the volume of the air. A device of this type has neutral vertical velocity stability. If it is rising or sinking, its buoyancy and speed will remain constant in spite of changes in depth.

This is the principle used in NOSC's fixed volume lift bags. This closed lift bag is always kept fully inflated at a few psi over ambient pressure. That portion of its volume which is not filled with air to provide buoyancy is filled with water to provide ballast. To increase the buoyancy, water is let out of the bag through a water valve. Water is pumped into the bag to decrease buoyancy. If water is let out of the bag or if the external pressure is increasing because the lift bag is descending, air is bled into the bag to restore the internal pressure differential. When water is pumped into the bag or the lift bag is ascending, excess air is vented out through a relief valve.

The fixed volume lift bag has been demonstrated in 5-ton and 3200-lb versions. Air and water have been supplied from the surface under diver control, and in the case of the Deep Ocean Recovery System (DORS) Lift Module, from a self contained air bank and water pump which were controlled by a micro-processor or a remotely operated vehicle.

An operational disadvantage of the fixed volume lift bag is its need for a water pump for ballasting. This disadvantage is avoided in a self-ballasting, fixed volume lift device which is known informally as the Jack-in-the-Bag due to its resemblance to a Jack-in-the-Box. A 500-lb capacity prototype Jack-in-the-Bag was fabricated and tested to demonstrate the feasibility of the concept.

DESCRIPTION

The Jack-in-the-Bag is essentially a fabric cylinder with rigid end plates. The components of the 500-lb prototype are shown in figure 1. Air for pressure compensation is contained in a standard 72-ft^3 SCUBA bottle and is supplied through a SCUBA regulator. Two air valves, V1 and V3, are located at the top of the device. V1 is used to turn off the pressure compensation air, and V3 allows air to be dumped from the bag. The tubing between the air valves and the regulator is a standpipe which acts as a relief valve for excess air. Valve V2 at the bottom of the device allows water to flow into or out of the bag. A hand operated water pump is used to add water when small buoyancy adjustments are required.

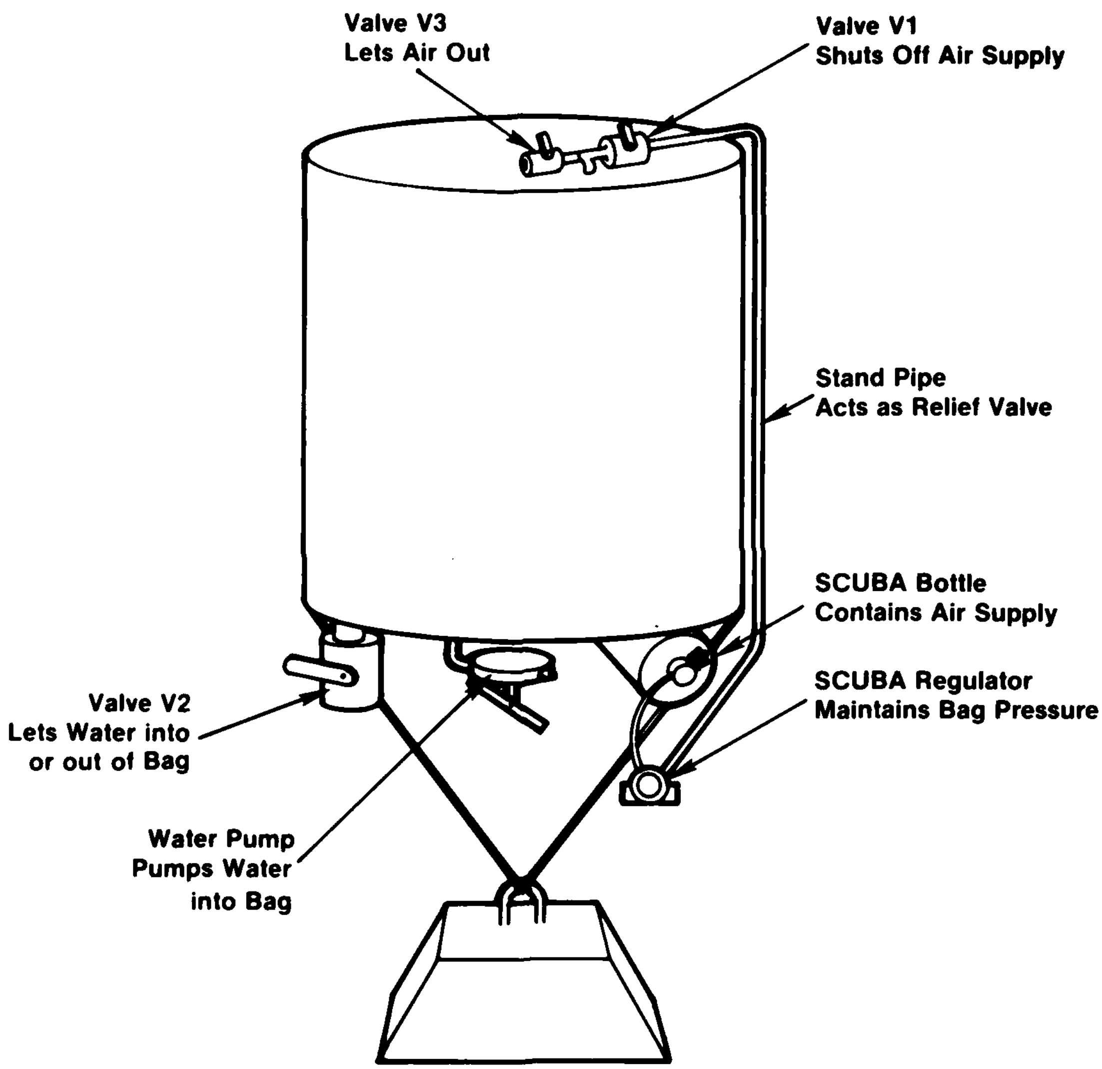

Figure 1. Jack-in-the-bag components.

OPERATION

Operation of the Jack-in-the-Bag is shown in figure 2. It is taken underwater in the contracted configuration with the valve on the SCUBA bottle open so that the regulator can pressure compensate itself and the length of standpipe up to valve V1. Valve V1 is shut so that the bag does not fill up with air, and valves V2 and V3 are left open to avoid squeezing the bag.

After it has been attached to the object to be lifted (figure 2a) valve V3 is shut, and valve V1 is opened briefly to inject a small amount of air into the device. The upper plate is lifted up by this air, and water is drawn in through valve V2 much in the manner of a bellows (figure 2b).

When the bag is fully ballasted, valve V2 is shut and V1 is opened to allow the SCUBA regulator to pressurize the bag. Since the regulator is about 4 feet below the top of the device, the interior pressure will be maintained about 2 psi higher than the ambient pressure at the top of the bag and, depending on the amount of water inside the bag, from 1/2 to 1-1/2 psi higher than the ambient pressure at the bottom of the bag.

At this point the Jack-in-the-Bag is ready for deballasting. Valve V2 is opened to allow water to flow out of the bag (figure 2c) until the load is just slightly negative. Then the valve is shut. The bag and its load can then be picked up and moved around on the bottom by a diver. If the load must be taken to the surface, more water is let out through valve V2 until positive buoyancy is attained. Then it is shut. As the bag ascends (figure 2d), excess air is vented out the standpipe and regulator which act as a relief valve.

The small hand operated water pump located at the bottom of the bag can be used to pump water into the bag to ballast it slightly negative if it is necessary to lower the load back down to the bottom (figure 2e). As the device descends (figure 2f), the SCUBA regulator puts air into the bag to maintain the air volume at its positive relative pressure.

To remove the Jack-in-the-Bag from the load, valve V1 is shut, valve V3 is opened to let out the air, and valve V2 is opened to let water into the bag (figure 2g). When it is on the surface ready to be picked up out of the water, valve V3 should be shut and V1 opened. Then valve V2 should be opened until all of the water is blown out of the bag (figure 2h).

TEST RESULTS

The Jack-in-the-Bag prototype was successfully demonstrated in both the test pool and the open ocean. Changes in its net buoyancy were made easily and accurately. In one test in the pool, after adjusting the device and its load to near neutral buoyancy, the diver was able to stand on the load and cause it to rise or sink by changing the volume of air in his lungs.

The addition of the hand operated water pump to the device greatly increases its flexibility over the original version, which did not have a pump. With it, the net buoyancy can be both increased and decreased while still maintaining neutral vertical velocity stability.

The best method for moving objects around seemed to be to keep them slightly negative and to pick them up and swim them from place to place.

Figures 3, 4, 5 and 6 are photographs of the Jack-in-the-Bag 500-lb prototype during its tests.

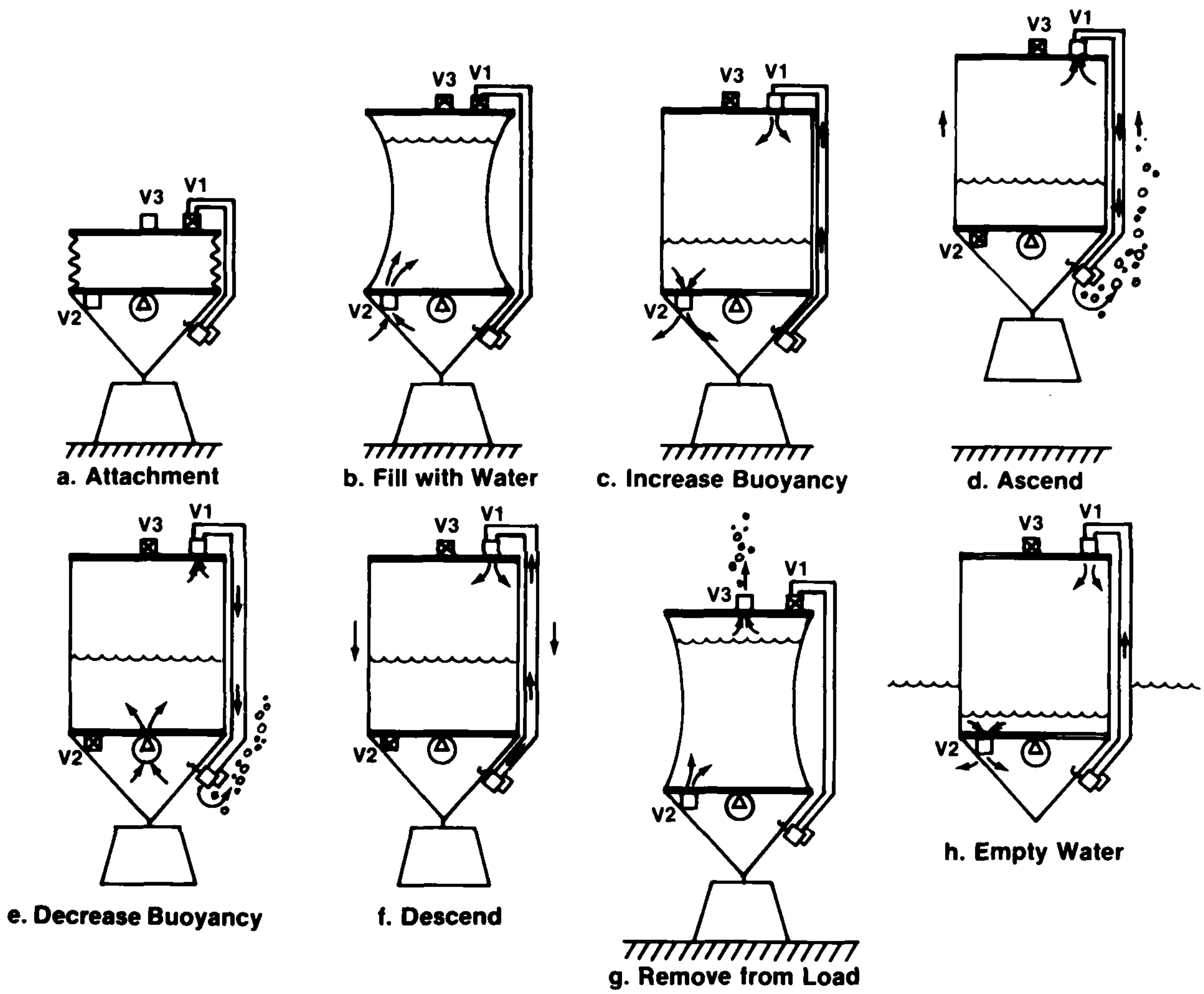

Figure 2. Modes of operation.

Figure 3. Collapsed for storage.

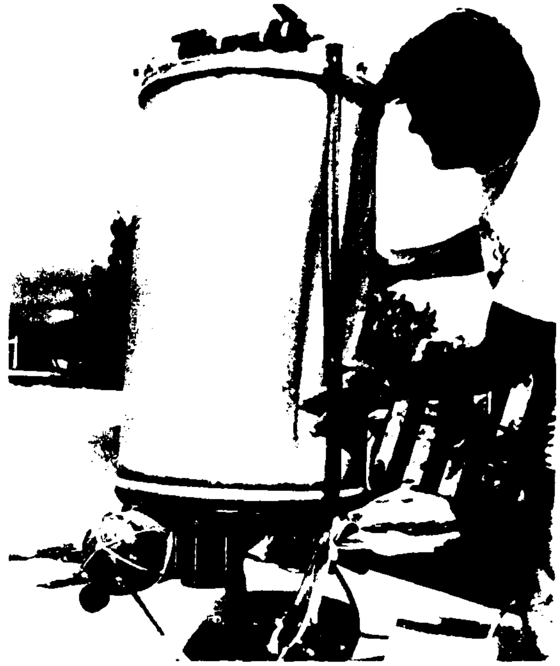

Figure 4. Extended for use.

Figure 5. Moving a heavy weight in Kaneohe Bay.

Figure 6. Demonstrating neutral buoyancy with a clump.

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